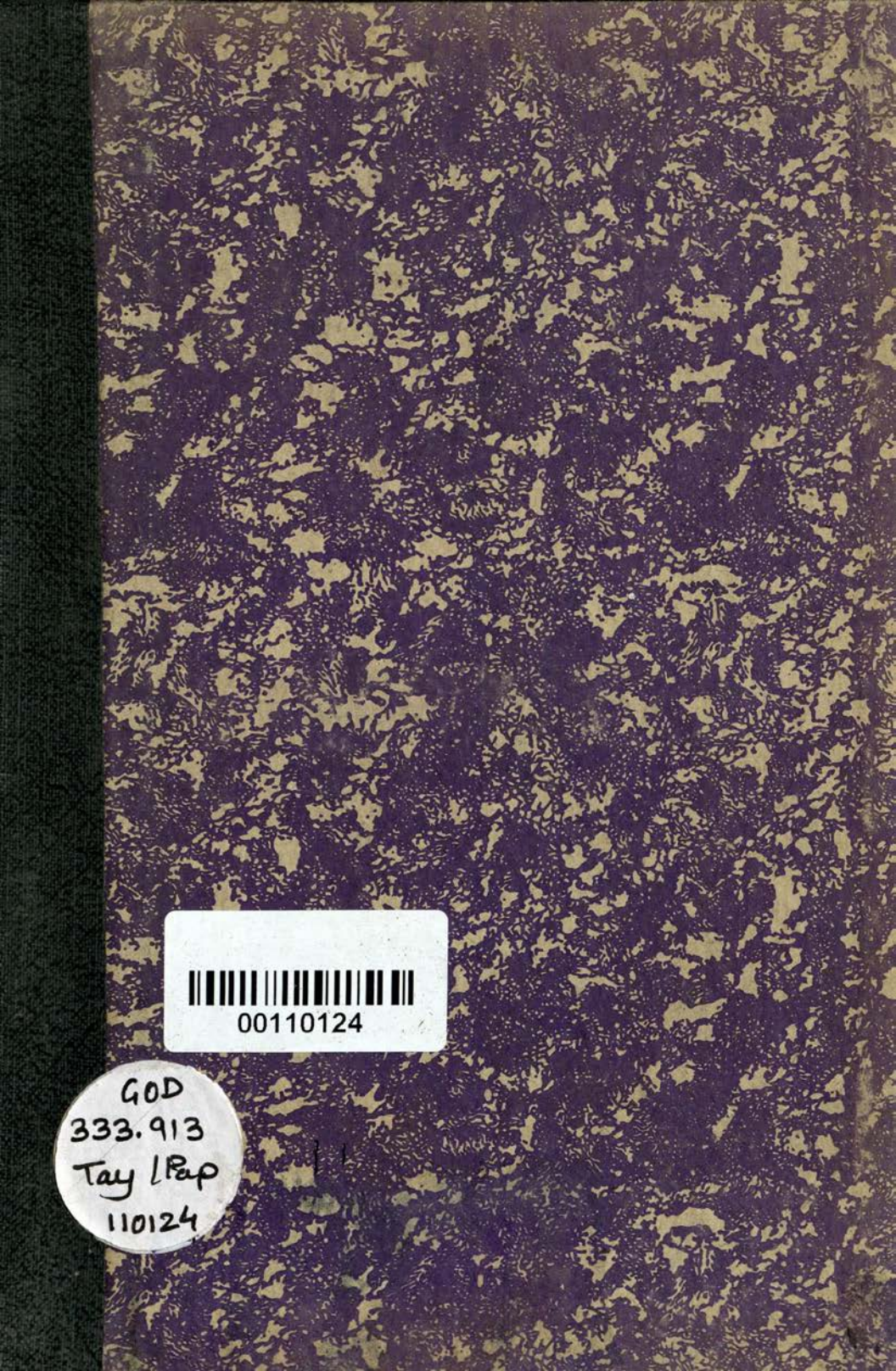
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PAPERS

ON THE

CONSTRUCTION OF TANKS FOR IRRIGATION

BY 110124

Capt. M. TAYLOR and Capt. BUCKLE.

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PAPERS ON THE CONSTRUCTION OF TANKS FOR IRRIGATION.

EXTRACTS FROM A LETTER FROM CAPTAIN E. BUCKLE TO GENERAL FRASER, IN REGARD TO THE FIRST PROPOSAL OF THE KUCHACKNOOR TANK BY CAPTAIN TAYLOR.

2. With reference to the proposed tank at Kuchacknoor, nothing can be more favourable than the features of the adjoining country, as described by Captain Taylor, and as delineated in that officer's plan of the country; but as the supply of the tank is restricted to the rain which may fall within a district of 7 square miles, it must fluctuate greatly.* Making the average fall of rain to be 30 inches, and assuming half that quantity to be retained by the tank, and made available for cultivation, it would afford irrigation for about 2,000 acres, which I suppose may be considered equivalent to a revenue of Rs. 12,000. In the absence of other data, I offer this as an approximate basis of calculation for comparing the cost with the returns of the undertaking.

4. With regard to the executive details of the work, Section No. 2, as proposed by Captain Taylor, is decidedly the best. It allows a breadth at top of 15 yards, where the bund is highest, giving the interior slope, which is to be faced with rough stone, a base equal to the height, and the exterior slope, where the soil will rest at its own angle of repose, a base equal to one and a half times the height. Three times the height would, however, have been a better proportion.

5. With an embankment of the above description, it is practically a matter of no consequence whatever whether its description be perfectly straight, similar to the Hussein Sagor Tank at this station, or whether it curve inwards or outwards, or both: the configuration of the ground will best regulate these details.

6. The rate assumed for earth-work in the estimate appears to be such as

* Captain Buckle, as he subsequently stated, had mistaken the scale of the map: the tank would have the drainage of 140 square miles.—M. T.

it might fairly be executed at; but there is an item for ramming down and consolidating the earth as it is thrown up. For this an addition of one-third is necessary to this part of the estimate. But in the estimated quantity of stone-work there is apparently a considerable error of excess, its thickness being entered at double the correct amount. It is intended that the facing throughout shall be 1 yard thick at top, and increase in thickness towards the bottom, so that, for instance, when the bund is 15 yards high, the facing will be 3 yards thick at bottom; its greatest average thickness would therefore be 2 yards instead of 5 yards, as entered in the estimate, and so on in proportion along the whole bund. On the other hand, the rate of 7 cubic yards per rupee for stone-work appears to me remarkably low, as this includes not only furnishing the materials, but building it up to the proper angle—an operation that becomes laborious and difficult as the work advances.* I may add here that no foundation is necessary for tank facings beyond a footing of two layers of stone; the facing never fails from a defect of foundation, but from the settling of the soil at its back. The estimate for the minor works of sluices and escape-weirs do not call for any remarks.

7. In conducting the execution of the work, it may be noticed that the bund should be carried on from the extremities towards the centre, leaving the closing of the nullah as the last operation; in doing this, care should be taken to remove the sand entirely, if possible, from the part where the bund crosses it, otherwise the tank will leak, or probably be undermined there. It is also advisable to build a solid wall along the front, where it is opposed to the direct action of the stream. This is sure to prove the weakest part of the bund, and in hill tanks, where the streams fill very rapidly, the water sometimes accumulates at this point, and overtops the bund before it has time to distribute itself over the basins of the tank. On this account, the level of the top of the bund here should be fully 12 feet higher than what is intended to be the high-water line of the tank. Along other parts of the bund, half this height will be sufficient. I may further observe, that the tank may be made available for cultivation before it is fully completed, by having passages for the escape of the overplus water at each extremity of the bund, proportioned to the progress of the work, and which may afterwards be built up to their proper or intended height.

In conclusion, I may state that the project appears to be one of great promise. The estimate bears a fair proportion to the benefit expected, and appears to be such as the work might be executed under. I am not so sanguine as to suppose the work could be completed in two years, but this is of little importance. It should be recollected, also, that the returns from a new work like this are always very gradual, and such as often to disappoint the

*The rate was finally settled at 8 cubic yards per rupee, including building, &c.; earth-[illegible]t 20 cubic yards per rupee.—M. T.

projectors; for it takes a considerable amount of agricultural labour and capital to prepare new lands for wet cultivation; but all such difficulties are overcome by time and management. The only material point to which I think Captain Taylor's attention need be drawn is that of satisfying himself of there being a sufficient hollow above the site of the bund for the retention of the supply at its assigned level. I am not inclined to suspect that the reverse of this is the case, but its possibility should be looked to beforehand.

(Signed) E. BUCKLE,
Superintending Engineer.

Secunderabad, 2nd July 1851.

REPORT ON PROPOSED TANK AT JEWURGEE.

From Captain M. TAYLOR,
On Special Duty, Shorapoor,

To Major General FRASER,
Resident, Hyderabad.

Camp Jewurgee, 10th May 1851.

SIR,

In reference to my former communications in regard to new tanks in the Sumusthan, I have the honour to bring to your notice that a large one may be constructed at this village, with apparent profit to the State, and at comparatively little cost, considering its size, owing to the natural advantages of the situation.

2. The nullah or river I propose to dam up is a considerable one, and, as you will observe by the Survey Sketch No. 1, has an ample supply of water in the drainage of about 64 square miles. The several branches originate in the high lands of Ijeyri, &c. and join before reaching the village of Ouradi.

3. Below Ouradi, the nullah flows on in an easy descent, and at the point I have selected for the bund, the ground on each side rises into natural elevations, which decline to the north and south, along which the bund will be carried, having a considerable part of low land to the north, which will be filled with water. The Survey Level No. 3 will show you the natural slope of the valley on each side of the point alluded to.

4. The bed of the nullah is bare limestone rock, and the same rock continues up each side of the valley from one yard to a yard and a half below the surface soil. I have satisfied myself on this point, by having holes dug at intervals along the crest of the ridge selected for the bund. The rock, therefore, affords a secure foundation for the bund, for the whole length, including the nullah, where the greatest pressure will occur.

5. The rock also affords an admirable natural advantage for the formation of the escapes at each end of the bund, for the surface earth being cleared away down to the rock at the highest water level, and for a sufficient breadth, the surplus water would flow over the rock itself in its natural declination to the north, and would join the main nullah at points below. There would be no danger of the nullah being affected by the surplus water, as the same stratum of rock continues to the village of Jewurgee, sometimes at the surface, sometimes a little below it.

6. The slope from the proposed bund towards Jewurgee is also eminently favourable on both sides of the nullah. The watercourse from the sluice would pass over solid rock between the points B and D of Sketch No. 1, with a fall of 33 feet in 1,970 yards from the escape, or end of the bund. After reaching the point near the south-east corner of the village of Jewurgee, the slope to the north-east is still more favourable, and the whole of the area between Jewurgee, Bootinhal, and Chennoor, and, indeed, to the Bheema, could be irrigated. The land here is of fine quality, and suitable for sugar-cane, rice, or any other valuable cultivation. The eastern stream from the tank would divide into two before it reached Jewurgee; the main stream would run to the south-east of the village; the other to the west and north, irrigating the land along the bank of the nullah, which is now used for garden cultivation.

7. The stream from the west side of the tank would pass the village of Jewurgee Khoord, irrigating the land down to the nullah, and after crossing a small tributary nullah at its proper level, would follow the northern or left bank of the main stream, as shown in the sketch, on which the land is of excellent quality also.

8. According to the village register of Jewurgee, the irrigable land stated in paragraph 6 is rather more than 1,000 beegas, and, including the land on both sides of the nullah from the sluices, the whole amount which is capable of being irrigated is at least 1,500 beegas, the whole being of fine quality, at present under dry and garden cultivation.

9. Land now irrigated, partly by throwing a temporary dam across the main nullah, after the rains, when there is a good running stream for four months, and partly by wells, pays rent at the rate of Rs. 7 per beega for sugar-cane, &c. and the people of the villages around have assured me that if certain irrigation were provided them, the land would produce this amount or more per beega. As Jewurgee is a large and populous village, and there are several others in its immediate neighbourhood, there is no fear that the land would not be taken up, as the certainty of return from irrigated lands makes them subject of much competition in this district wherever they are situated.

10. There being no doubt, therefore, as to the occupation of the land, its amount, the only question is as to the supply of water in proportion [redacted] land; and on this point I regret that I have no standard for computation,

and have omitted to put the question for Captain Buckle's consideration in my former letters.

11. I have, however, taken the level of the tank from the highest water level, as given in the elevation of the bund, carefully with a theodolite, and find that the area (vide Sketch No. 2) is about 3,750,000 square yards, which, allowing an average depth of 4 yards, gives 15,000,000 cubic yards of water. Did I possess any data as to the general expenditure of water per beega or per acre per annum for irrigation, it could at once be seen how many acres or beegas the tank would supply; but should you do me the favour to refer this communication for Captain Buckle's consideration, I would beg his kind attention to this point, as a full understanding of it would render mistakes impossible in any future calculation or proposal regarding new tanks.

12. Judging from the eye, however, and the depth of water, I should consider that the tank would be fully equal to the irrigation of at least from 500 to 600 beegas, which, at the rate assumed, would afford a fair return on the amount to be expended. The level taken by me is, however, lower than it might be by 6 feet, and should, as I consider would be perfectly practicable and advantageous, another 6 feet be added to the bund, as calculated in the supplementary estimate, the area would be very considerably increased, as well as the depth of water by 3 feet, and the running water, which continues to flow freely in the nullah till the month of March, would go far to supply the evaporation. From October to January the stream is considerable, and would, I am of opinion, of itself form a supply equal to one channel for irrigation.

13. I am of opinion there would be no doubt of a full water supply even at the increased level; indeed here, as at Kuchacknoor, there is more apprehension from an over-supply than a short one; but by arranging adequate escapes, in proportion to the size of the river at flood, I should not anticipate danger; and as I have remarked, the natural advantages in regard to the rock beneath the surface on each side are very great.

14. The amount of land to be submerged, and which would belong to Jewurgee Khoord and Ouradi, is 1,329 beegas according to village estimates, and the rent now paid to the Sirkar is in Ouradi Rs. 104; in Jewurgee Khoord Rs. 20; total Rs. 124.

15. The greater portion of the Ouradi land is covered by date trees, and is uncultivated. The loss to be [illegible]ected from these is about Rs. 200 per annum. The cultivated land is generally of poor quality.

16. Materials for the construction of the tank are abundant. The earth is of a stiff clayey quality, but easily dug. On the west side of the valley the trap hill affords large trap rocks, which can be removed without difficulty, as they lie on the surface, and are not too large for the purpose. On the west side laminar limestone rock can be raised at the surface close to the bund,

and is readily broken by the wuddawars into blocks of any size required, about 8 to 12 inches thick.

17. In the Sketch No. 1 you will observe another site of a tank laid down in the ravine leading from Ijeyri, and this I should propose to construct, should the supply of water prove much in excess of that required for the large tank. The expense of this tank would not exceed Rs. 5,000, as the ravine is narrow where the bund would be. Below the tank there would be a large extent of land belonging to Ouradi and Hulgudli, of superior quality, and the whole of the villagers are as anxious to have water for irrigation as those of Jewurgee. Materials also in stone (trap rock) and earth are most abundant, and easily worked. The Ijeyri branch of the nullah has always a small stream running through it.

(True extract)

(Signed) M. TAYLOR,
On special duty.

From Captain BUCKLE,
Superintending Engineer, Hyderabad Subsidiary Force,

To Major General FRASER,
Resident, Hyderabad.

SIR,

I have the honour to acknowledge the receipt of your letter of 27th instant, together with the communication from Captain Meadows Taylor, which accompanied it, suggesting the construction of a new tank near the village of Jewurgee, in the Sumusthan. These papers I have carefully perused. The representation made of the features of the country, on which the success of the project depends, are eminently favourable to it; but the report would have been more complete could a series of levels have been given from Ouradi to the site of the bund, and two or three cross levels at right angles with such a line. However, as the fall from D to B is 33 feet in 1,970 yards, perhaps the fall from Ouradi to D is less than this, though the distance is nearly twice as great. Of course, unless it is so, the water could not be retained, as proposed, for the whole height of the bund is only calculated at 33 feet, and it would not be safe to retain the water within 9 feet of its crest in the centre. The ordinary obstacle to the construction of tanks in hilly situations is the difficulty of finding a suitable basin, the land falling too rapidly.

2. I agree in opinion with Captain Taylor, that the supply of water in ordinary seasons promises to be abundant, and as the bed of the tank is said

to be underlaid with limestone, there would be little probability of the project being defeated by leakage, an event I have known to occur.

3. The proposed sections of the work and provisions of sluices and escape-weirs appear suitable, and the estimate for them sufficiently accurate, though I apprehend it may be found not quite equal to the whole outlay. The top of the bund should be coated with gravel, both for its preservation, and that it may be available as a road. Some provision, also, is necessary for the extensive irrigation channels.

4. The very small quantity of cultivated land which will be sacrificed by this work is an unusual advantage; and as the ryots of Jewurgee seem familiar with wet cultivation, the resources which it is proposed to open to them would probably be rapidly availed of to a considerable extent. But in the Company's territories this has usually been observed to be a much slower process than might be expected. In considering the advantages and disadvantages of the work, of course the claims of any existing channels from the nullah or tank, drawing a supply from it, have been regarded.

5. The information which Captain Taylor in paragraph 11 expresses a desire to obtain I can easily supply. Rice cultivation requires a cubic yard of water for a square yard of land: this is the simplest practical rule that can be given. Another calculation is, that an acre of paddy requires a constant flow of two cubic yards of water per hour for a hundred days. This amounts to the same proportion as the first within a minute fraction. Colonel Cautley, at the Dooab Canal, computes that a cubic foot of water per second is equal to the irrigation of 218 acres, or about 660 beegas. This also will be found very nearly to coincide with the rate above given, supposing that a perennial flow is understood.

6. Captain Taylor's calculation of the area and probable depth of the tank would lead to the conclusion of the projected work affording irrigation to 1,500 acres of land*; but what the assessment on this would be I have no means of judging, the Shorapoor beega being altogether different from the Bengal beega; nor do I know to what degree this land may be under dry cultivation, and what its assessment. Judging only from what is before me, this would appear to me a more profitable speculation than the Kuchacknoor project, but I should suppose that undertaking any one work of this description would demand all the resources of the Shorapoor district to complete it within two years.

I have, &c.

(Signed) E. Buckle,
Superintending Engineer.

Secunderabad, 31st May 1851.

* A Shorapoor beega is about one-third less than an acre; that is, a beega contains 3,364 square yards, an acre 4,840.—M. T.

EXTRACTS FROM A LETTER FROM CAPTAIN TAYLOR TO MAJOR GENERAL FRASER, SUBMITTING ESTIMATES, &c. FOR A TANK AT SIRWALL.

4. The nullah at Sirwall has, as you will observe by the Survey Sketch No. 1, which is enlarged from the trigonometrical survey map, a drainage of 82 square miles of country. Its sources are on the high lands of the Sumusthan beyond Gogi, and one branch of it already supplies two tanks at Gogi, which are in repair, and are used for irrigation. The remainder is ample for a very considerable, and to some extent permanent, supply of water to the new tank at Sirwall.

5. I now beg your examination of the Plan of the tank and bund No. 2. You will observe that the nullah, after passing the village of Itgi, follows an irregular course to the north-east, until it reaches the point A; thence east to B, where it suddenly turns nearly due south to C, and then again north-east by the village of Sirwall. At the points C and D the stream is turned by a rocky elevation, the summit of which is about 50 feet above the bed of the nullah, and at C the rock rises with a steep ascent to the height of the elevation above A and B, so as to render comparatively little work necessary at this end.

6. From the north end of the bank, the slope is gradual to the bed of the river at C D, while the rocky portion E E, including the bed of the nullah, not only furnishes an admirably secure foundation for the bund, but actually contributes its height above the river to the bund itself, as well on the north as on the south side of the river, leaving only the aperture of the channel C D to be filled up to the level determined, and that level to be carried on to the extreme point.

7. Another advantage appears to me observable from the course of the nullah. When a bund is constructed at right angles with a stream, it must necessarily follow that a great force and pressure of water, when the nullah is in flood, must occur at first at the point crossed by the bund; but in this situation the direction of the current of water from B to C would be parallel to the bund, and the force of the current would be first expended against the rocky elevation above C. After the water should rise above the level of the ordinary bank of the nullah, the force of the current would be directed against the hill above A B; and thus I consider that while the distance from A to C gives ample room for the subsidence of water to its proper level, there would be no pressure from the current on any part of the bund.

10. The land to be irrigated will depend in proportion, of course, to the water which is secured in the tank. At the lowest level, Estimate No. 1,

the whole of the land on the left side of the nullah down to the Bheema, which amounts to upwards of 600 beegas, to which water could be directed from Sluice No. 1, could be irrigated ; and it is possible, also, from the natural supply by the nullah during four months, that another channel, taken from the Sluice No. 2 to the south of the village of Sirwall, would afford a supply for another tract of irrigated cultivation on the right bank. This, however, would be dependent upon the result of the drain from the Sluice No. 1. The slopes of the lands on both sides of the nullah down to the Bheema, and even to the village of Hoorus Goondugee, are most favourable, and on the right bank of the lands of Sirwall and Hoorus Goondugee could be irrigated to a very great extent.

11. Advocates the higher estimate of the two, on account of the large addition of water.

12. Material is most abundant: earth of a very firm quality is dug from the opposite side of the nullah. It contains a large proportion of white lime (kunkur), and binds readily and strongly. Besides the limestone rock of the locality, which is raised from its beds in blocks or slabs as required of 8 to 12 inches thick, there are a great number of ruined and unfinished temples near the spot, and blocks of granite and limestone squared by the chisel, which have been brought from a distance, and at immense cost. These being of no use to any one, I have employed them in the work going on. Many of these blocks of granite, which have been brought from 8 to 10 miles distance, are 10 to 12 feet long, and 1½ foot to 1 foot square, and are invaluable for the foundations and facings of the bund. Indeed, the presence of this costly and readily prepared material, which could be applied to a useful purpose, mainly influenced me in deciding upon the small bund or weir for the usual stream, which can be so easily and profitably extended.

13. The escapes or calingulahs of the tank have now to be considered. It is most probable that in an ordinary monsoon there would be a greater supply of water from the river, notwithstanding the depth of the tank, than it could contain, and therefore outlets must be provided, equal or superior to the amount of water passing a given point in the river, a yard in breadth.

14. The highest flood level remembered by any one of Sirwall or Itgi gives a breadth of 160 yards, with a depth of 6 feet. This would give a stream of about 120 cubic yards of water, or say 400* cubic feet, for which escapes should be provided in case of emergency.

15. The facilities for arranging this are very great. On both ends of the bund the solid rock is met at 2 feet from the surface. The surface soil being removed, therefore, and one layer of the laminar rock, which lies in horizontal strata, or as many as might be required to reduce the level by 1 foot per 150 yards on each side, would suffice; the excess of water over this being already provided for by the excess of the bund over the water level. (Vide Plan No. 4.)

* Sic in original, a mistake in copying.—M. T.

16. The bund being carried along a ridge, the slope of the rock towards the tank and backwards is about equal, and while this slope secures the escape of the surplus water, the solid rock prevents any chance of the ground behind being undermined; and the surplus would fall into the old channel of the river below the bund from each calingulah.

17. If the bund were carried up to the highest level, as per Estimate No. 2, the facilities for the escape of the water surplus would be even improved; for at that level the south end is near a natural watercourse, which falls rapidly down the elevation to the river, into which the surplus water could be directed; and on the north end there is no difficulty, as the rock continues the same as at the lower elevation, with an equally advantageous fall. There is no masonry of any kind required for the calingulah on either side, the natural rock being level, firm, and smooth, and in every way suited to the purpose.

Paras. 18, 19, 20 relate to details in the estimate of no material consequence.

21. The return of the tank may be estimated as follows:—

At the lower level, Estimate No. 1, 600 beegas of land, at Rs. 7 per beega for the first four years, Rs. 4,200 per annum. Afterwards the land would bear a higher value, and as far as Rs. 10 per beega, or even more, in good spots for sugar-cane and rice cultivation.

22. If the higher level were determined upon, the increase would be in proportion, but to what extent I am unable to state, from having no data on which to calculate the expenditure of water per beega; but there is no doubt that land to a greater extent than on the left bank of the nullah can be irrigated on the right; and allowing that between the two the tank was equal to the irrigation of 1,000 beegas, at the same rate, the returns to be expected appear to bear a fair proportion to the capital employed.

Camp near Shahpoor, 11*th June* 1852.

From Captain BUCKLE,
Superintending Engineer, Hyderabad Subsidiary Force,
To Major General FRASER,
Resident, Hyderabad.

Dated 28*th June* 1851.

Para 2. The Plan No. 1, showing the basin of the Sirwall nullah, affords satisfactory evidence of the supply of water by that stream being equal to the demands of a large tank, and the report discusses the eligibility of constructing a large tank at the cost of Hyderabad Rs. 15,000, or a very large one at double the sum.

3. The former project contemplates a depth of 28 feet of water along the deep of the tank, the latter a depth of 40 feet in the same part. The smaller would be clear of the village of Itgi, the larger would encroach upon it.

The evaporating surface of the larger tank would be double that of the smaller; but the relation of the cubic contents of the one to the other cannot be determined in the absence of cross levels. The area of the bed of the smaller tank appears to be about 500 acres, and the irrigation under it might amount to 1,000 acres, or 1,300 Shorapoor beegas. The assessment on the latter is rated at Rs. 7,500, on which computation the outlay on the tank would be defrayed by two years of full cultivation, or, allowing favourable cowles for clearing and preparing the land, the expenditure would be reimbursed at the end of five years. Under the prospect of enlarging the tank, it will be advisable to make the stone facing 2 yards thick at top, as this will admit of an additional height of 5 or 6 yards being given to it without difficulty. I may again call attention to the circumstance of a stone facing not being a rivetment, but merely a protection against the action of the waves. Instead of yielding support, it requires support, and there is no advantage in making the thickness at bottom more than 3 yards, or the thickness at top more than 1 yard, the slope forming an angle of 45°. It is preferable to build the facing in steps rather than with a smooth surface, as this forces the tank diggers to select their material. The cut stone mentioned in paragraph 12 of the report would, I think, be out of place in the stone facing: it might be well to reserve it all for the sluices and calingulahs.

6. The advantages derived by the tank in its bund running parallel with, instead of perpendicular to the stream is, as Captain Taylor points out, a very considerable one. It will not be possible to calculate the dimensions of the calingulahs from the section of the nullah, as adverted to in paragraph 14, unless the velocity of the stream were also ascertained at the same time; but it may safely be assumed that two calingulahs 150 yards, or even 100 yards each in length, as suggested in paragraph 15, and on the level shown in Plan No. 4, would be sufficient to relieve the tank in case of floods after it was filled.

7. In paragraph 14, the oversight has been made* of considering 400 cubic feet as about the equivalent of 120 cubic yards: the figures should be 3,240 feet; but this is of no practical importance.

8. If eventually it should prove expedient to raise the bund so as to contain an additional depth of 12 feet of water, I may point out that the crest of the bund ought to be 3 yards clear of the high flood level, although 2 yards may be sufficient for the smaller work: in raising the bund, the object is to secure it from being washed over or injured by waves during storms, and waves are proportioned to the depth of water and the distance they traverse.

9. Deep tanks are certainly preferable to shallow ones; but no tank that affords a depth of 15 feet of water can be considered shallow, and the Sirwall tank on the lowest scale is computed to contain 28 feet of water.

10. The estimates for the tanks have been carefully prepared, and are likely to be found adequate, as the stone facing may be reduced one-third of that provided for.

* It was a clerical error.—M. T.

11. There is one point of great importance relating to the sites of tanks which I have not seen noticed in the reports on those proposed to be constructed in the Shorapoor State, and that is in their soil; but I presume that none of those contemplated lie in black cotton soil, as their beds would otherwise soon fill up, and the ploughing for wet cultivation in this soil is found destructive to cattle. Such tanks are usually soon abandoned.

12. The only difficulty I experience in offering a definite opinion upon the merits of the site selected for tanks by Captain Taylor, arises from the absence of more detailed and well ascertained levels*; for, presuming that the soil is of a description which can be traversed without being extensively dissolved by water, and is adapted for the plough when under irrigation, the different positions recommended for embankments appear judiciously chosen, and the details of construction well arranged. I have made such remarks as appeared necessary in this and former letters on details connected with stone facings, the height of bunds, and the dimensions of calingulahs, while at the same time the estimates are sufficiently exact for the purposes to which they are intended to apply.

(Signed) E. BUCKLE,
Superintending Engineer, Hyderabad Subsidiary Force.

EXTRACTS FROM CAPTAIN BUCKLE'S LETTER TO GENERAL FRASER, 18TH MARCH 1851, ON THE SUBJECT OF THE KUCHACKNOOR TANK.

A remark in paragraph 2 of this report inclines me to think that the concluding observation of my letter of 2nd January may prove deserving of careful investigation. Captain Taylor speaks of the Kuchacknoor river "as flowing 12 inches deep, and 3 yards broad, with a strong current." Assuming the rate of current to be nearly 2 miles per hour, the fall by computation would amount to 16 feet per mile, at which rate the water would attain 32 feet at the bund, when the bed extended only 2 miles.

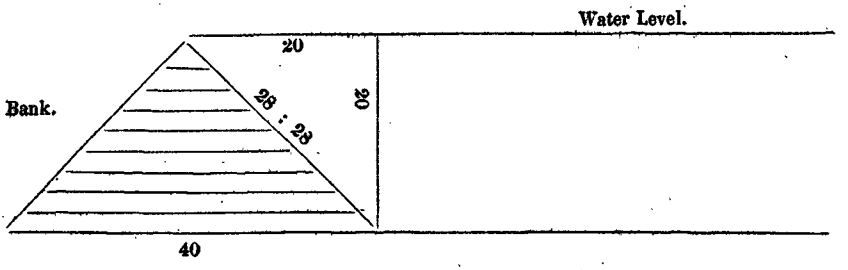
The contribution of this stream during the drier months at the rate above given would amount to 84,000 cubic feet per diem, thus: $\frac{1}{3} \times 3{,}520 \times 3 \times 24 = 84{,}000$ cubic yards; but taking the area of the tank to be reduced to 6 square miles, and the evaporation to be only a quarter of an inch per diem, we shall have a loss of water amounting to cubic yards 129,066, thus:—

$$1760^2 \times 6 \times \frac{1}{144} = \frac{3097600}{24} = 129{,}066 \text{ cubic yards.}$$

* I had no instrument then.—M. T.

Or the loss by evaporation is half as much again as the supply by a stream 3 yards broad, 1 foot deep, and flowing at the rate of 2 miles per hour. I may add that the evaporation is probably stated at too low a figure, and if this stream has a more rapid flow than 2 miles an hour when 1 foot deep, it would indicate a still more rapid fall than 16 feet per mile.

This may be a proper place for offering some remarks on the subject of the dimensions of a weir for the relief of the tank. The area of the tank when full may be taken at 10 square miles, and it may be considered desirable to possess the power of reducing this 1 foot in depth in the course of twenty-four hours, that is, to afford the tank a capacity of discharge of 835,752,000 cubic feet of water in twenty-four hours. To effect this, a weir 300 feet long and 4 feet below high-water level is necessary,* but considering the numerous feeders to this tank, and its general features, I should be disposed to recommend two such works of outlet, one at each end of the bund. I may further remark, that a weir of one-half the depth, or 2 feet, would discharge only one-third the same extent of water. The next point on which I may offer a remark is that of the stability of an earthen bank as opposed to the pressure of water, and a reference to the subjoined diagram and calculations will show that an earthen bank offers a resistance more than two and a half times that of the pressure of the water against it when it rises to a point, and its sides standing at an angle of 45°:—



	Specific gravity of water 1,000	
	Ditto of earth 1,900	
28·28	Surface under pressure	20
10	Centre of gravity below surface..	20
282·8		400 contents of section.
1,000		1,900
282,800	pressure of water.	760,000 weight of bank.

P : W :: 282,800 : 760,000; or as 1 : 2⅞ nearly.

* The weir will be 300 yards long, and have a capacity of discharge of 3 feet water, equal 2,700 feet. Captain Buckle's two weir escapes would give 2,400 feet.—M. T.

Whatever, therefore, is added to this, is merely on account of the subsidence of the earth-work, and the effect of storms, as well as of the elements, and accidents generally. It will of course be recollected, that loose earth occupies nearly half as much space again as when in its natural state, and that it takes years to consolidate, unless beaten down in course of construction. It is the more expedient, also, to do this in order to obviate the danger of fissures, and the burrowing of vermin.

With reference to paragraph 12 of Captain Taylor's memorandum, I may observe, that the additional pressure generated by a velocity of 10 feet per second would still be very far from equalling the resistance of the mere mass of earth, as noted above.

As regards foundations to the stone facing, I may repeat that nothing but a footing is required: its tendency is not to sink but to slide; it follows the changes which take place in the soil behind it.

EXTRACT FROM CAPTAIN BUCKLE'S LETTER TO GENERAL FRASER, DATED 30TH JUNE, ON A MEMORANDUM SUBMITTED TO GENERAL FRASER FOR CAPTAIN BUCKLE'S INFORMATION.

3. In estimating the returns from the tanks, I may draw attention to the circumstance of sugar cultivation demanding a larger consumption of water than rice.

4. I may observe in reply to what is stated in paragraph 3, that it is by no means indispensable to coat the tops of tank banks with gravel, but merely a desirable course when practicable. The exterior slope of the bank should also be planted with low shrubs, to protect the earth from being washed down: for this purpose the aloe is a useful plant.

5. With reference to paragraph 6, I am of opinion that with a smaller area of tank, larger calingulahs are not necessary; the calingulahs determined on being equal to the discharge of any body of water likely to be brought down by the feeders of the tank. If the calingulahs were supposed equal to preventing the level of the larger area from rising, they will be still more effective in regard to a smaller area.

6. When I assumed 6 square miles to be the probable area of the Kuchacknoor tank, the daily evaporation was computed at 129,066 cubic yards; but the present estimated surface is 2 square miles, at which rate the evaporation becomes 43,022 cubic yards.

7. A correction is also required for the contributions of the nullah in the

dry season. The latter on the former occasion was estimated at a breadth of 9 feet, depth 1 foot, and fall of 16 feet per mile: now it is given at a breadth of 9 feet, depth ½ foot,* and fall of 12 feet per mile. This reduces the contribution from 84,000 cubic yards to 23,520 cubic yards per diem. The evaporation from the tank must be computed on its medium area of surface, but it cannot be safely assumed at less than 30,000 cubic yards per diem, which is in excess of the nullah's contribution during the dry season. It may, therefore, be sufficient to consider these two items of receipt and expenditure as balancing each other.

(Signed) E. Buckle.

OBSERVATIONS ON THE CONSTRUCTION OF TANK BUNDS BY CAPTAIN M. TAYLOR.

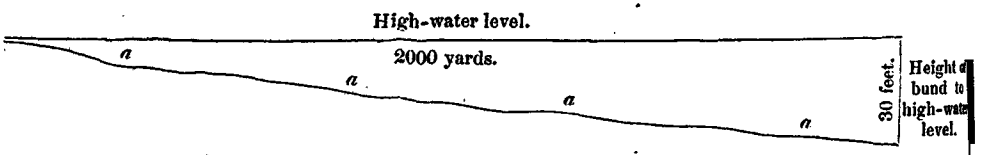
1. *The Site.*—This should always have reference to the sides of the valley which can be easiest joined together, and to the basin above it; also to the material on the spot. The less fall there is in the bed of the stream the better, and it frequently happens, that after a series of rather rapid falls a stream runs tolerably level for some distance, and falls again. This level should form the basin of the tank. If the fall of the stream should be over 12 or 16 feet in a mile, the height of bund required would be very considerable, and more expensive than where less fall and more basin, and consequently not so high a bund, were required. If a natural basin, as it were, is selected for a tank, it would hardly matter very much whether the land to be irrigated were close at hand or not: it might be at a distance of a mile, or even two, and the channels for irrigation being properly made and banked up, there would be very little waste of water.

2. Having fixed upon the site, the levels across the valley from point to point, or end to end of the proposed bund, should be taken. This is best done by a levelling instrument, or Y level, but it can be done by any Native Karkoon with a 10-foot mason's level, which is easily managed, and if there be not much wind is tolerably correct, and quite sufficiently so for any purposes of estimate.

3. There should also be some levels taken up the stream, till the level attained corresponds with the height of the bund, or the amount of depression

* There was a difference in the seasons as regards the water: Captain Buckle had assumed 16 feet fall per mile; the measurement by levels proved it to be only 12 feet. No rain had fallen in June, and the water was only half the depth it was in January. I suspect the January stream would be a fair average.—M. T.

of the valley, as taken from either end or side of the proposed bund, which will show—



Level taken along the bed of the stream, *a a a a*.

the length of the tank, and two or more levels at right angles at any distances most expedient, which, with the level up stream, and that of the bund, will be data enough, not only to show the basin of the tank, but to calculate the amount of cubic feet of water or yards it may contain, which will lead to estimates of irrigation.

4. When the size of the tank and the length and height of the bund are decided upon, the bund can be marked out for execution, and an estimate made of its cost. This had better be done *from each end*, according to the fall in the ground.

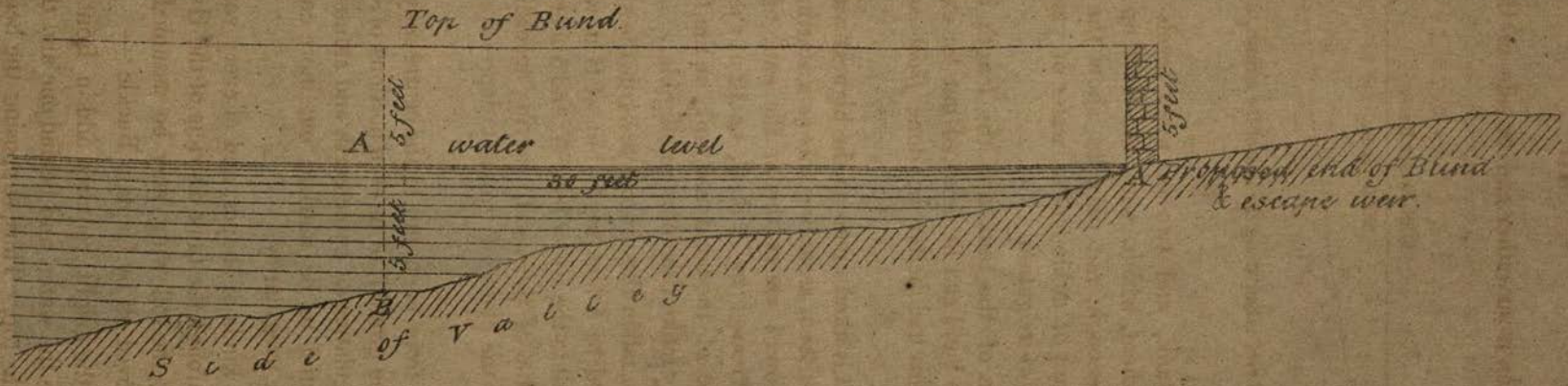
5. Say that a spot is fixed upon as the highest water level of the tank on the side of the valley; then, assuming this as a starting point, there should be 5 or 6 feet bund allowed above this at the end, to continue all along the bund, and to be increased to 7, 8, 9, or 12 at the centre, or highest part, according to the size of the bund and tank, or the force of the stream. The annexed diagram may make this more intelligible.

There is therefore a fall in the ground towards the stream of 5 feet in 30 feet. At A the bund would be 5 feet high, but at B it would be 10 feet; that is 5 feet from the ground to the water level A, and 5 feet above it; and so it would continue from each end of the bund, varying according to the ground to the centre, or wherever the place of greatest depression (that is the bed of the stream) might be.

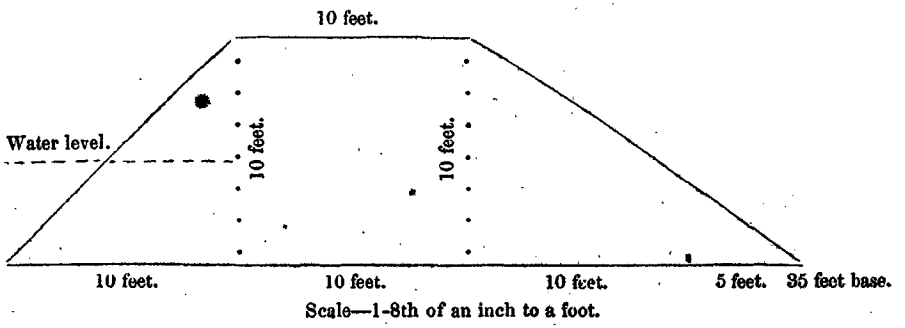
6. The distance from each end to the centre may be marked off into portions, according to the ground, or in even portions of say 50 or 100 yards each. This makes the calculation of cubic earth and stone-work more easy, enables the shape of the bund to be marked out more correctly, and obviates any chance of mistake or irregularity.

7. Bunds of all kinds of shapes, and of every variety of thickness at base and top, are found through the tank districts of the Hyderabad country; but as a general principle, the following may be assumed as correct and safe data, and have been approved off by Captain Buckle:—

8. To a cube of the height required add in front half a cube, forming an angle of 45°, to face the water, and behind one and three quarters of the cube, as a slope up to the top. Thus, supposing the height of the bund, say at B


Top of Bund
A
5 feet
water
level
5 feet
5 feet
30 feet
B
Side of Valley
5 feet
Proposed end of Bund
& escape weir.

of former diagram, to be 10 feet, then for the half cube in front 10 feet, and behind 15 feet, total 35 feet of base; and the shape may be thus illustrated :—



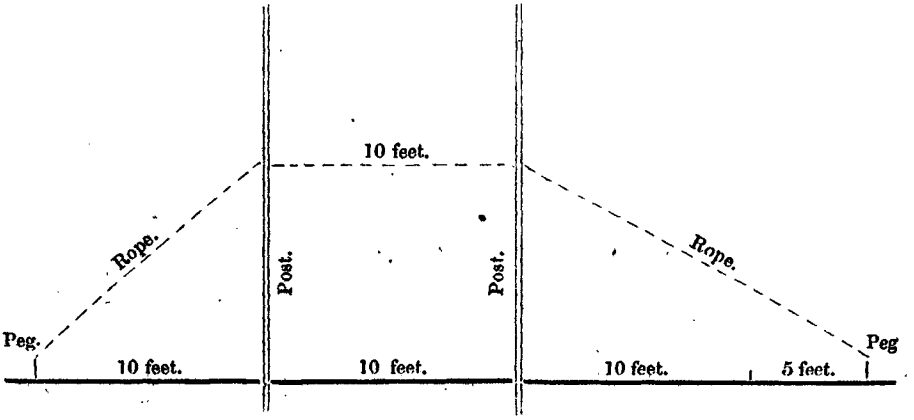
Scale—1-8th of an inch to a foot.

9. As this plan, if exactly adhered to, would give hardly sufficient roadway on the surface of the bund, where the height is insignificant, it may be as well to begin with 12 feet width at top, and proportional base, until, by the gradual increase of height in the bund, the proper roadway at once appears. Should 12 feet not be considered sufficient, 18 may be taken, which, when the height of the bund became 6 yards, would be the proper proportion for the top, and would require, of course, a proportionate base, on the scale given above.

10. Supposing, however, that the bund is very high in the centre, there would be no occasion to follow the rule exactly here. At top, for instance, if the bund were 50 feet high, the breadth of the top need not be more than 12, or at most 15 yards wide, while the *base* would require to be on the scale already laid down. By attending to this point, something may be saved in the cubic earth-work of the bund, and it is worth attention. Captain Buckle points out that the breadth at top gives no additional security whatever; the top might just as well be a point as broad; but having a broad top is useful as a roadway, and all superfluous earth, after a certain period, is washed down to the base, or settles itself in its natural angle of repose. The face to the water may be even at a more abrupt angle than 45°, but behind the slope should be as gradual as possible, not only on account of the greater base required (and secured by it), but because there is less chance of its being cut up by water-courses, or washed down by water from above.

11. On these data, the whole of the bund may be marked out by bamboos and string or rope. Two strong bamboos or poles are provided to mark the sides of the centre cube; the distance for the base is measured off, and pegs driven into the ground. String or rope is then fastened to the bamboos as they lie on the ground at the point of the cube, and when the bamboos are raised and the ropes fastened to the pegs, the skeleton of the bund appears perfectly, and has only to be filled up by the workmen. It is necessary,

of course, that the poles should be firmly let into the ground, and secured from moving.



12. If this plan is carried on all through the portions of the bund, the whole skeleton appears at once; but as the work should be carried on from the ends to the centre, it is, I think, better to set up the skeleton posts only as the "numbers" are wanted by the contractor or workmen, one or perhaps two at a time. Great attention should be paid that the work is done *quite* up to the highest level or the top of the bund, as this saves much subsequent trouble.

13. As each number or portion is finished, the levels should be ascertained by a 10-foot mason's level, both on the top and along the high-water line, as this serves, with the calculation from below the water line, to keep the work correct. The levels should of course be taken from the original points of departure.

14. *Stone Facing.*—The earth-work should be faced with rough stone, which prevents the action of waves or the water generally upon the earth-work. It is not necessary that the stone-work should be very thick, but the stones should be as large as possible, as they then settle by their own weight, and are not liable to be displaced. A small foundation is, I think, necessary: sufficient to hold two rows of stones one upon another is enough where the ground is pretty firm beneath; but if any portion is very soft, it would be advisable to dig down to the moorum or hard earth, and lay the stones upon it. The stone-work at the bottom should be 3 *yards* in breadth for the bund of an ordinary large tank, or for a bund which say measures 30 feet to the high-water level. In the low portions of the bund, 2 yards broad for the foundation might be enough, gradually decreasing to the higher portions. Supposing the base to be 3 yards broad, it should rise gradually, decreasing to 1 yard broad at top, which is sufficient for all purposes, though 2 yards is preferred by the Natives, or at least 1½ yard. If it is proposed to raise the

bund afterwards, there should be stone-work of at least 2 yards broad left at the top, on which further superstructure can be raised.

15. The earth and stone-work may go on simultaneously if desired, and as is the general custom, but I understand it is sometimes the practice* to allow the earth of the bund to settle during a whole monsoon without any stone facing, and when the earth-work is being completed to the height &c. required the stone facing is done with it. By carrying on both works together, however, the constant passage of the wuddawars' carts loaded with stone over the newly thrown up earth, undoubtedly tends to consolidate it in a great degree, and as the wuddawars cannot build up from below, as masons, but drive their carts up the earthen mounds, from whence the stones are rolled down the slope to the men working below, all the stone necessarily passes over the earth, and with the result I have stated. I suspect it does not much signify which of the two systems is followed. Captain Buckle advises the ramming or beating down of the earth, which would be doubtless very advantageous, but very expensive. The Natives do not follow this practice, but allow the bund to settle well for at least two monsoons before the nullah is filled up and the tank filled. If the earth were beaten down as thrown up, I should think a tank might be ready the first year. It is of course most advisable to begin earth-work in the monsoon, when, being wet when raised, and constantly wetted by showers, it binds, and settles more firmly than it otherwise would.

16. Data will be found in my reports, and Captain Buckle's observations on them, for the formation of calingulahs or escape-weirs. They should possess ample breadth for the discharge of superfluous water, after the highest level of water in the tank has been attained; and unless a high safety portion of the bund is left, which will allow with safety one or two feet of water to remain temporarily till the proper level is reached, the escape had better be constructed so as to allow of no accumulation whatever, or as little as possible, say a few inches. Data for the length of the calingulahs may be obtained from a calculation of the water in the nullah when at flood, and the height (depth) and breadth of the water being given, and if possible its velocity, the amount of cubic feet to be discharged will appear from the calculation.† It is far better to be on the safe side, and to allow for a greater discharge of water by one-half than appears from the nullah; the calingulah, also, should be made as wide as possible, to admit of the water flowing over it in a shallow stream; for it is almost unnecessary to state that the more a volume of water is compressed, the greater is its force; and the shallower it is, the

* In the Madras Presidency.

† The section of the nullah at Kuchacknoor gave 2,250 square feet of water in flood; velocity allowed at 6 feet per second, or 4 miles per hour, discharge per second 13,500 cubic feet. A calingulah 600 feet long, and having a depth of 3 feet, yields discharge as follows: Velocity $= 8 . v = 8 v. 3 = 8 \times 1.732 = 13.856$ feet per second. This multiplied by 600, and 3, the length and height, gives $13.856 \times 600 \times 3 = 24{,}941$ cubic feet per second; from whence it appears that the water would flow at hardly 2 feet depth over the calingulah.

less action it has on the masonry of the calingulah, or on the surface of the ground over which it runs.

17. Should, as at the tanks of Sirwall and Jewurgee, the escape-weir be made upon solid rock, there is no occasion for masonry, except at the end of the bund adjoining the outlet; and where, for some little distance, it may be a rivetment, built with chunam or rough stone. The end of the bund is here the only object for precaution, as the water cannot disturb the solid rock. But should the place of escape be moorum only, or hard soil resting upon moorum, masonry would be necessary. In this case the ground should be dug out as deep as may be requisite, say one or two yards, and a foundation filled in with stone and gravel mixed with lime, and beaten down. On this the structure of the calingulah can be raised to the water level of the tank, or a little below it, say 6 inches; but the water level is safe enough if the width of the calingulah be sufficient for the surplus water to flow off, say a foot or 18 inches deep, or even less, if it can be so arranged. As I have said, the shallower the flow of water the better, though there appears no danger as far as even 3 feet depth.

18. Most of the large tanks in the Hyderabad country have upright stones, about 5 or 6 feet high, built into the crest of the calingulahs at intervals of 6 or 10 feet. By these, into which branches are entwined, backed by mud or clay, a foot or more of extra water can be retained in the tank above the ordinary high-water level; while, in case of any sudden flood, or pressure upon the high part of the bund, the whole can be cleared away in a few minutes, or is broken down by the water itself in flood. A diagram of this arrangement is annexed. (Diagram 1.)

This is a convenient plan, and if Natives are used to it, attended with no danger; but after all, when the water level has been determined at the highest available point, it may be safer, on the whole, not to allow more water to be retained in the tank.

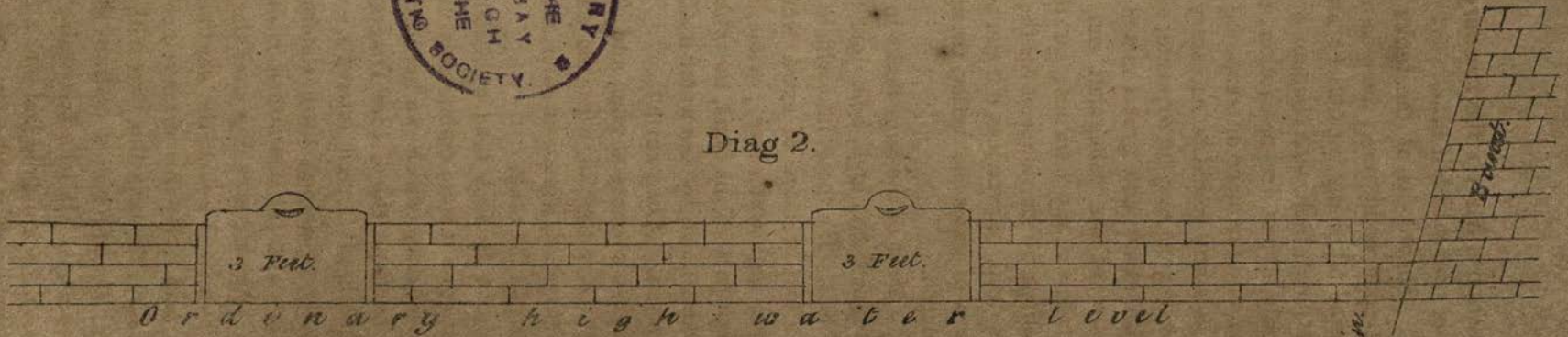
19. At Bohnal I have introduced another principle, which is to have sluices, or as it were embrasures, in the crest of the calingulah, 3 feet wide and 18 inches deep, which can be filled up with wooden shutters, for which grooves have been provided. (See Diagram 2.) These extend along the whole of the calingulah, at 3 yard intervals. When, therefore, the flood in the tank is gradually subsiding, these sluices can be shut *one by one* at intervals, corresponding with the diminished rush of water. When they are all shut, a small stream of water may flow over the top of all, till it gradually subsides. Should any extra flood follow, the shutters can be easily withdrawn, and relief given to the tank. By this arrangement 12 inches more water than before was retained in the tank this year without any risk whatever.

20. The apron or slope from the crest of the calingulah may be arranged in various ways. If on a favourable slope of hard ground, a pavement of large heavy stones, carefully laid into a bed of mortar, or, as is very often the case, without mortar, is sufficient. (See Diagram 3.) The length and slope of this

Diag. 1.

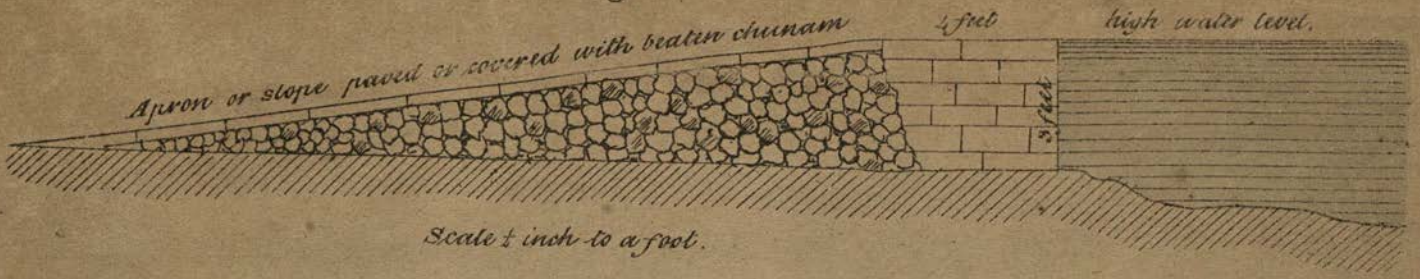
ROYAL ASIATIC SOCIETY LIBRARY OF THE BOMBAY BRANCH OF THE

Diag 2.



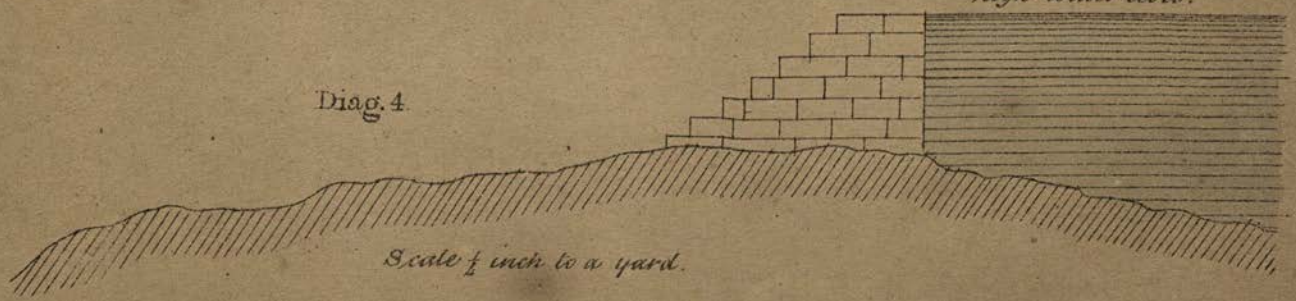
Scale ½ inch to a foot

Diag. 3.



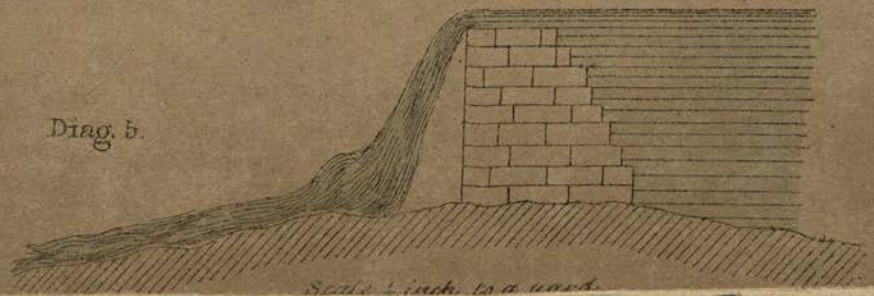
Scale ½ inch to a foot.

Diag. 4.



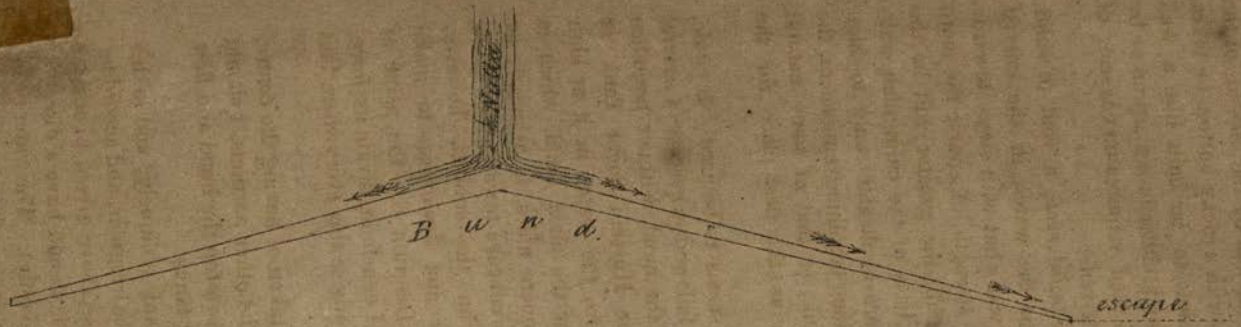
Scale ½ inch to a yard.

Diag. 5.

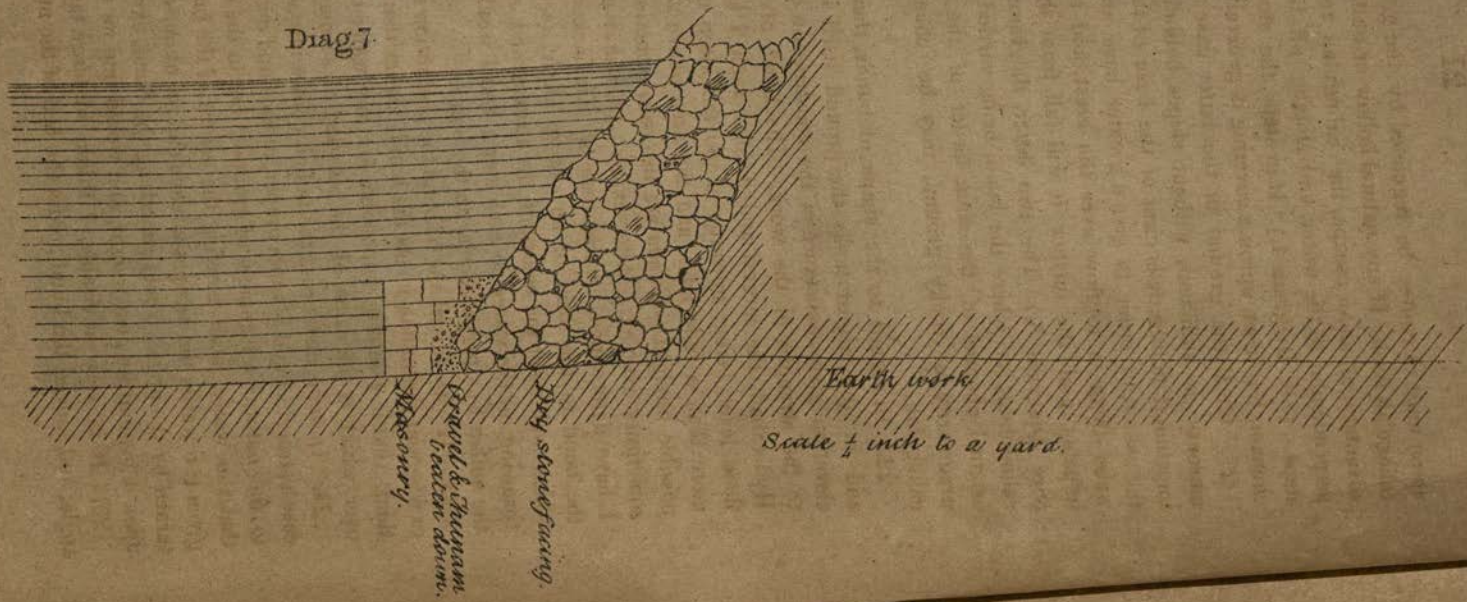


Scale ½ inch to a yard.

Diag. 6.


B w r d.
escape

Diag. 7


Earth work
Masonry.
French & Neuman beaten down.
Dry stone facing.
Scale 1/4 inch to a yard.

apron must of course be regulated by the ground, and by the height of the calingulah itself. If any natural hollow or nullah with a rocky bottom be taken advantage of, as an escape, the calingulah requires to be built like a wall perpendicular to the water, and sloping off behind either in an apron or by steps. (See Diagram 4.) If in steps, the stone used requires no covering of chunam, but in an apron a covering is generally given.

21. Or if the ground in the latter case be *solid rock*, a wall of solid masonry is sufficient, without slopes behind, as the water, in the curved impetus of falling, falls clear of the base of the wall; but with steps towards the water, in order to give a greater base and strength, of course the more water there is to flow over the crest, and to fall, the greater will be the impetus, and the further it will fall from the base of the calingulah wall. (See Diagram 5.) The two latter diagrams are applicable only to high calingulahs, or where the bund, being carried along adjoining eminences, the original channel of the main feeder of the tank, or that of some natural irregularity of rocky ground, may be chosen as the best place for the calingulah.

22. In regard to the shape of bunds, there seems to be hardly any rule, and in the largest tanks the ground itself is followed wherever a natural elevation gives assistance in the construction of the bund, without prejudice to the strength of the work. The bund of the Hussein Sagor Tank at Hyderabad, the largest and deepest tank I know, the water in it at high flood level being upwards of 50 feet deep near the main bund, which is more than a mile long, and the area above 2 square miles, is as nearly as possible straight. Bunds are also seen sometimes concave towards the water, sometimes convex. After much consideration on the subject, however, I have determined, in the case of Kuchacknoor and Jewurgee, to make the bund in the form of an obtuse angle, (see Diagram 6,) the point of which well meet the centre of the stream, and, as I conclude, divide its force, throwing off the water to each side; and I would advise this everywhere that the nullah was perpendicular to the bund.

23. If with this shape of bund the precaution is taken of having the centre, or whereon the nullah meets the bund, higher than the other portions, I should think that it would be impossible for any water to overtop the bund and flow over, which is the cause of the bursting of so many tanks.

24. In some instances, the nullah comes into a tank obliquely, and in this case a straight bund is quite proper, or the bund may be irregular, and according to the natural advantages of ground; but in the case above given, I consider that the water, after meeting the centre of the bund, should have a direction given it towards the escapes at each end (or at one end only). The water being turned by the angle, would run along the bund, exercising no force or pressure upon it beyond its own weight, and would find its way out of the escape.

25. It is very advisable, I think, in large tanks, that the bottom of this angle, and indeed the bund across the bed of the nullah, should be laid in with

chunam. This would prevent leakage, or the chance of the force of the current and pressure displacing any of the stones of the facing. Two yards high of such masonry across the breadth of the nullah would, I conceive, be quite sufficient, and would give great security to the work above. The work need not be of cut stone; rough stone, with the side edges smoothed, laid in with good mortar, and a backing of gravel and chunam concrete, well beaten down, would be sufficient for all purposes. At the back of this would follow the rough stone facing, and the earth as before shown. I shall finish the nullahs at Kuchacknoor, Jewurgee, and Sirwall, all of which are rock, in this manner. (See Diagram 7.)

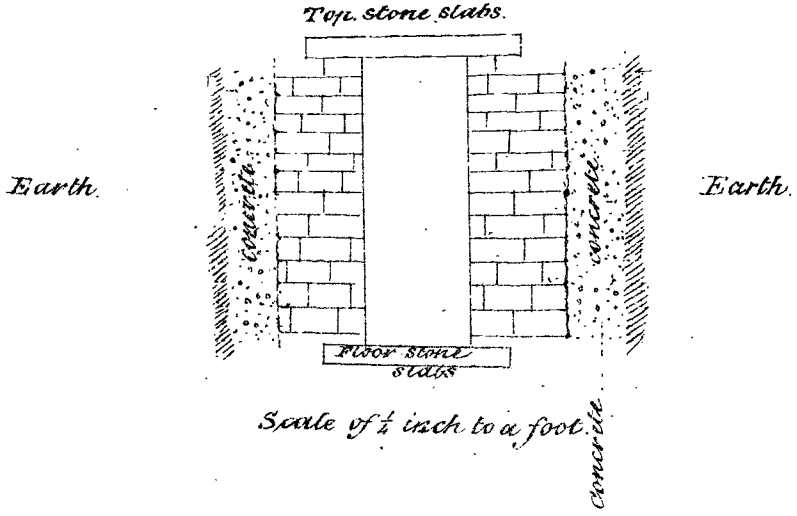
26. In regard to sluices, there is little to be said, as the Natives seem to understand them perfectly. If the tank is not very large, two are ordinarily sufficient for irrigation, one on each side of the nullah. They may be made at different elevations of the bund, or on the same level, according to the ground and land to be irrigated. Should the whole of the land to be irrigated be on one side of the nullah, there may be two sluices, one at a higher and one at a lower level.

27. In some tanks the sluices are so constructed, that the whole of the water in the tank may be drained off; but it is desirable, I think, always to have some in the bed, as, if quite dry, the ground is very apt to crack suddenly, and the more so from having been wet. These cracks may extend under the bund, and lead to leaks, which are very difficult to stop, and often undermine the centre of the bund. Should the ground be rock, however, there could be no apprehension. Still, a little water is always of use, and might remain, if only to break the force of the first flood streams after the monsoon begins.

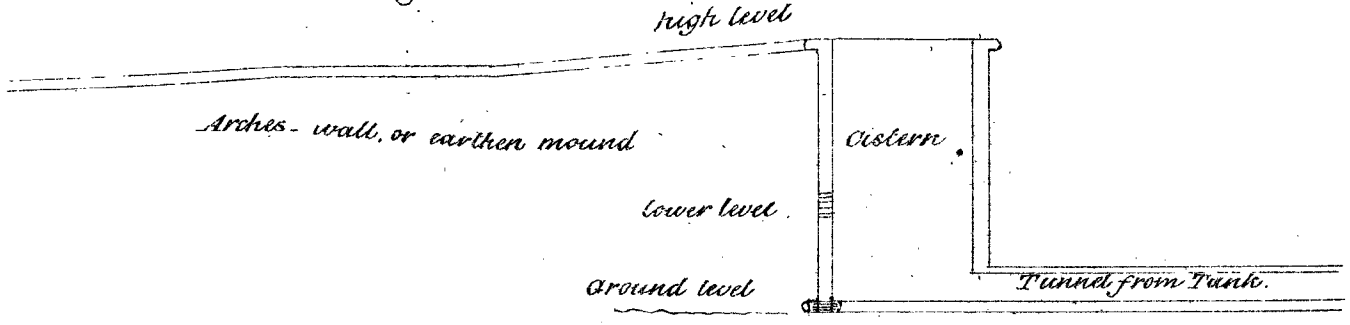
28. In constructing sluices, it is most necessary to see that the sides are very strong, and that there is no chance of lateral leaks, which would wash away the earth from the sides, and probably injure the bund, or even break it, as I have known to be the case. I would therefore advise, besides the masonry, that gravel and chunam concrete should be well beaten in behind the masonry, and between it and the earth. (See Diagram 8.) This plan will, I think, effectually prevent side leakage, and it might also be introduced where the front portion of the sluice, or chabootra as it is called, joins the bund.

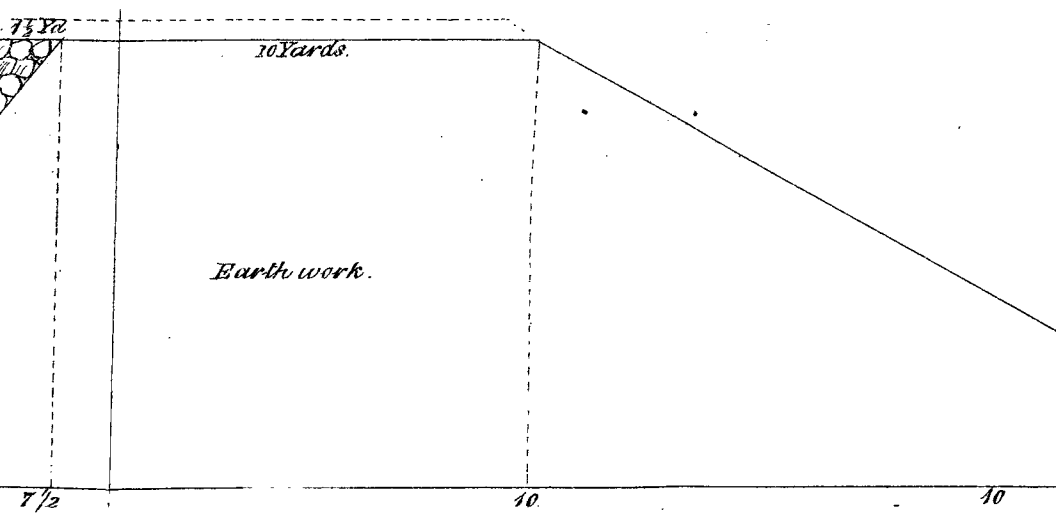
29. In regard to taking off the water for irrigation, there are usually in large tanks two, or even three levels given in the sluice itself. All these can be opened in heavy floods to relieve the tank, and one at a time is used, according to the water level in the tank. The water, from whatever level used, falls into the channel (tunnel) under the bund, and then rises in the cistern behind to the same level, or something lower than the hole of the sluice used. From this cistern there are holes, which carry off the water to the channels, according to the height of water in the tank or cistern, either by earthen mounds, or, as I have seen, by channels made upon masonry walls, or upon arches, and carried to a neighbouring elevation, from whence it is directed into the general irrigation channel. (See Diagram 9.)

Diag. 8.


Top. stone slabs.
Earth.
Concrete.
Concrete.
Earth.
Floor stone slabs
Scale of ½ inch to a foot.
Concrete.

Diag. 9.


high level
Arches - wall, or earthen mound
Cistern
lower level
Tunnel from Tank.
Ground level



Scale 1 inch to a yard.

30. There is nothing which at present occurs to me to require further explanation, and I therefore close these remarks. I may, however, state, in reference to the concluding part of paragraph 10, that I think it advisable on the whole that the face of the bund towards the tank should have a *less* inclination at first than 45°, because during the settlement of the earth and stone-work, the latter falls naturally against the earth, and the whole assumes gradually an angle of 45°, and it may be arranged on this principle. (See Diagram 10.) Or if the top be considered too broad, there may be a proportion taken off these, with a proportionate reduction of the base. It is, however, very desirable to have as wide a base as possible, and as easy a slope from the top as can be arranged in the highest part of the bund.

It is necessary, also, to remark that the earth-work should be 2 or 3 feet above the stone-work facing. This provides for the gradual subsidence of the earth, which should be watched carefully, and more earth added, as necessary, till the whole is perfectly level and firm.

(Signed) MEADOWS TAYLOR.

Camp at Jewurgee, April 2nd, 1852.

SHORAPOOR SUMUSTHAN.

Estimate of proposed Tank at Jewurgee, Talooka Andola.

Portions of Bund.	MEASUREMENT. Long.	Broad.	High.	Total.	Amount at 15 Cubic Yards per Rupee.	Grand Total.
	Yds.	Yds. ft. in.	Yds. ft. in.	Cub. Yds. ft. in.	Rs. a. p.	Rs. a. p.
No. 1	100	5 0 11½	1 1 6	796 2 3	53 2 0	
2	100	6 0 7¾	2 1 8¼	1,592 2 0	106 3 0	
3	154	9 1 7	4 0 9	6,234 2 5½	415 10 0	
4	208	17 1 10½	8 0 9	30,244 1 6	2,016 5 0	
5	30	25 1 6	11 1 6	8,797 1 6	586 8 0	
6	10	25 1 6	11 1 6	2,932 1 6	195 8 0	
7	100	22 0 4½	10 0 0	22,125 0 0	1,475 0 0	
8	100	17 0 4½	7 2 1	13,176 2 2	878 7 0	
9	100	11 1 6	5 0 9	6,037 1 6	402 8 0	
10	200	7 2 3	3 0 9	5,037 1 6	355 13 6	
11	160	5 1 6	1 1 6	1,320 0 0	88 0 0	
Total..	1,262	....	....	98,295 1 4½	6,553 0 6	6,553 0 6
	STONE-WORK.				At 7 Cubic Yards per Rupee.	
No. 1	100	2 0 0	1 1 6	300 0 0	42 14 0	
2	100	2 0 0	3 1 6	700 0 0	100 0 0	
3	154	2 1 6	6 0 0	2,310 0 0	330 0 0	
4	208	3 0 0	10 0 0	6,240 0 0	891 7 0	
5	30	3 1 6	14 1 6	1,522 1 6	217 8 0	
6	10	3 1 6	14 1 6	507 1 6	72 8 0	
7	100	3 0 0	12 1 6	3,750 0 0	535 11 6	
8	100	2 1 6	9 0 0	2,250 0 0	321 7 0	
9	100	2 1 6	6 1 6	1,625 0 0	232 2 3	
10	200	2 0 0	4 0 0	1,600 0 0	228 9 3	
11	160	2 0 0	2 0 0	640 0 0	91 7 0	
Total..	1,262	....	....	21,445 0 0	3,063 10 0	3,063 10 0
	Miscellaneous Charges.					
2 Sluices					800 0 0	
20 Candies of Lime					320 0 0	
2 Escapes					100 0 0	
Native Writers, &c.					120 0 0	
Overseer, Sepoys					120 0 0	
Contingencies, Oil, &c.					100 0 0	1,560 0 0
				Total.... Hyderabad Rupees		11,176 10 6
Add amount for extra works, as per Supplementary Estimate.....						1,132 0 6
				Grand Total.... Hyderabad Rupees		12,308 11 0

Camp Jewurgee, 10th May 1851.

M. TAYLOR.

Supplementary Estimate of Additional Work recommended to the proposed Tank at Jewurgee.

Portions of Bund.	Earth-work.					Stone-work.				Grand Total.
	Long.	Broad.	High.	Total.	Amount Cost.	Long.	Broad and High.	Total.	Amount Cost.	
	Yds	Yds.	Yds.	Yds.	*Rs. a. p.*	Yds.	Yds.	Yds.	*Rs. a. p.*	*Rs. a. p.*
No. 1	100	3	2	600		100	1	100		
2	100	3	2	600		100	1	100		
3	154	3	2	910		154	1	154		
4	208	5	2	2,080		208	1	208		
5	30	8	2	480		30	1	30		
6	10	8	2	160		10	1	10		
7	100	7	2	1,600		100	1	100		
8	100	6	2	1,200		100	1	100		
9	100	5	2	1,000		100	1	100		
10	200	4	2	1,600		200	1	200		
11	160	3	2	960		160	1	160		
	1,262	0	0	11,190	746 0 0	1,262	0	1,262	180 4 6	926 4 6
Extra work at East end.	100	3	3	900		100	3×1	300		
West end.	100	3	3	900		100	3×1	300		
	200	0	0	1,800	120 0 0	200	0	600	85 12 0	205 12 0
									Total..Hyderabad Rupees	1,132 0 6

M. Taylor.

Estimate No. 2, for Tank at Kusba Sirwall, 1851.

Portions of Bund.	Long.	At Base.			At Top.			Total.	Average at the rate of half.			Average of succeeding No. or Portion.			Total.			Net Average.			At beginning of each Portion.			At end of each Portion.			Total.			Average.			Earth-work, Total Cubic Yards.			Amount of Cost, at 15 Cubic Yards per Rupee.		
Yds.	Yds.	Yds.	ft.	in.	Yds.	ft.	in.	Yds.	Yds.	ft.	in.	Yds.	ft.	in.	Yds.	ft.	in.	Yds.	ft.	in.	Yds.	ft.	in.	Yds.	ft.	in.	Yds.	ft.	in.	Yds.	ft.	in.	Yds.	ft.	in.	*Rs.*	*a.*	*p.*
1	157	8	0	0	4	0	0	12	6	0	0	9	1	6	15	1	6	7	2	3	1	2	0	5	0	0	6	2	0	3	1	0	4,055	2	6	270	6	0
2	37	15	0	0	4	0	0	19	9	1	6	11	1	6	21	0	0	10	1	6	5	0	0	6	0	0	11	0	0	5	1	6	2,136	2	3	142	7	0
3	77	18	0	0	5	0	0	23	11	1	6	14	1	6	26	0	0	13	0	0	6	0	0	8	0	0	14	0	0	7	0	0	7,007	0	0	467	2	0
4	83	23	0	0	6	0	0	29	14	1	6	20	0	0	34	1	6	17	0	9	8	0	0	10	2	0	18	2	0	9	1	0	13,363	0	0	890	14	0
5	105	32	0	0	8	0	0	40	20	0	0	22	1	6	42	1	6	21	0	9	10	2	0	12	0	0	22	2	0	11	1	0	25,287	1	6	1,685	13	0
6	100	36	0	0	9	0	0	45	22	1	6	26	0	0	48	1	6	24	0	9	12	0	0	14	0	0	26	0	0	13	0	0	31,525	0	0	2,101	11	0
7	153	42	0	0	10	0	0	52	26	0	0	28	0	0	54	0	0	27	0	0	14	0	0	15	1	6	29	1	6	14	2	3	60,932	0	9	4,062	2	3
8	100	46	0	0	10	0	0	56	28	0	0	29	0	0	57	0	0	28	1	6	15	1	6	16	0	0	31	1	6	15	2	3	44,887	1	6	2,992	8	0
9	76	48	0	0	10	0	0	58	29	0	0	31	0	0	60	0	0	30	0	0	16	0	0	16	1	6	32	1	6	16	0	9	37,050	0	0	2,470	0	0
10	37	54	0	0	14	0	0	68	34	0	0	34	0	0	68	0	0	34	0	0	18	0	0	18	0	0	36	0	0	18	0	0	22,644	0	0	1,509	9	6
11	73	50	0	0	12	0	0	62	31	0	0	18	0	0	49	0	0	24	1	6	16	1	6	9	0	0	25	1	6	12	2	3	22,803	1	½	1,520	3	9
12	37	28	0	0	8	0	0	36	18	0	0	14	0	0	32	0	0	16	0	0	9	0	0	7	1	6	16	1	6	8	0	9	4,884	0	0	325	9	9
13	200	22	1	6	5	1	6	28	14	0	0	6	0	0	20	0	0	10	0	0	7	1	6	1	2	0	9	0	6	4	1	9	9,166	2	0	611	1	9
14	..	8	0	0	4	0	0	12	6	0	0	..			..			..			1	2	0	..			..			..			....			....		
	1,235	..			..			..	..			..			..			..			..			..			..			..			285,742	2	½	19,049	6	0
	1,050	Foundation.													..			2	1	6	..			..			..			0	2	0	1,750	0	0	175	0	0
Total.	1,235	..			..			..	..			..			..			..			..			..			..			..			287,492	2	½	19,224	6	0

Stone-work.

Portions of Bund.	Long.	At Base.	At Top.	Total.	Average at the rate of half.	Average of succeeding No. or Portion.	Total.	Net Average.	At beginning of each Portion.	At end of each Portion.	Total.	Average.	Stone-work, Total Cubic Yards.	Amount of Cost, at 8 Cubic Yards per Rupee.
	Yds.	Yds. ft. in.	Yds. ft. in.	Yds.	Yds. ft. in.	Yds. ft. in.	Yds. ft. in.	Yds. ft. in.	Yds. ft. in.	Yds. ft. in.	Yds. ft. in.	Yds. ft. in.	Yds. ft. in.	*Rs. a. p.*
1	157	1 0 0	1 0 0	2	1 0 0	2 0 0	3 0 0	1 1 6	2 0 3	6 0 9	8 1 0	4 0 6	981 0 9	122 10 0
2	37	2 1 6	1 1 6	4	2 0 0	2 0 0	4 0 0	2 0 0	6 0 9	7 1 6	13 2 3	6 2 7½	508 2 3	63 9 6
3	77	2 1 6	1 1 6	4	2 0 0	2 1 6	4 1 6	2 0 9	7 1 6	10 0 0	17 1 6	8 2 3	1,515 2 9	189 7 6
4	83	3 0 0	2 0 0	5	2 1 6	3 0 0	5 1 6	2 2 3	10 0 0	13 1 0	23 1 0	11 2 0	2,662 2 9	332 15 6
5	105	4 0 0	2 0 0	6	3 0 0	3 0 0	6 0 0	3 0 0	13 1 0	15 0 0	28 1 0	14 0 6	4,462 1 6	557 13 0
6	100	4 0 0	2 0 0	6	3 0 0	3 0 0	6 0 0	3 0 0	15 0 0	17 1 6	32 1 6	16 0 9	4,875 0 0	609 6 0
7	153	4 0 0	2 0 0	6	3 0 0	4 0 0	7 0 0	3 1 6	17 1 6	19 1 6	37 0 0	18 1 6	9,906 2 3	1,238 5 6
8	100	5 0 0	3 0 0	8	4 0 0	4 0 0	8 0 0	4 0 0	19 1 6	20 0 0	39 1 6	19 2 3	7,900 0 0	987 8 0
9	75	5 0 0	3 0 0	8	4 0 0	4 0 0	8 0 0	4 0 0	20 0 0	20 2 0	40 2 0	20 1 0	6,181 1 0	772 10 6
10	37	5 0 0	3 0 0	8	4 0 0	4 0 0	8 0 0	4 0 0	22 1 6	22 1 6	45 0 0	22 1 6	3,330 0 0	416 4 0
11	73	5 0 0	3 0 0	8	4 0 0	2 0 0	6 0 0	3 0 0	20 0 2	11 1 0	32 0 0	16 0 0	3,004 0 0	438 0 0
12	37	2 1 6	1 1 6	4	2 0 0	2 0 0	4 0 0	2 0 0	11 1 0	9 1 6	20 2 6	10 1 3	770 2 6	96 5 9
13	200	2 1 6	1 1 6	4	2 0 0	2 0 0	3 0 0	1 1 6	9 1 6	2 0 3	11 1 9	5 2 4	1,737 1 6	217 3 0
14	..	1 0 0	1 0 0	2	1 0 0	..	..	..	2 0 3	..	..	..	....	....
	1,235	..	..	..	..	..	..	..	..	..	..	..	48,336 2 3	6,042 2 3
	1,050	Foundation.						2 1 6	..	..	..	0 2 0	1,750 0 0	209 6 0
Total.	1,235	..	..		..	..	..	..	..	..	..	..	50,086 2 3	6,251 8 3

Memorandum of Costs.

	Rs.	a.	p.
Earth-work, including digging of foundation..	19,224	6	0
Stone-work, do. laying of do.	6,251	8	3
2 Sluices	900	0	0
2 Escapes	150	0	0
30 Candies of Lime	480	0	0
Native Writers	180	0	0
Overseer, Sepoys	180	0	0
Contingencies	200	0	0
Compensation for Itgi and Hundrahal Estimate	2,500	0	0
Total ....Hyderabad Rupees	30,065	14	3

M. TAYLOR,
On Special Duty.

Camp near Shahpoor, 11*th June* 1851.

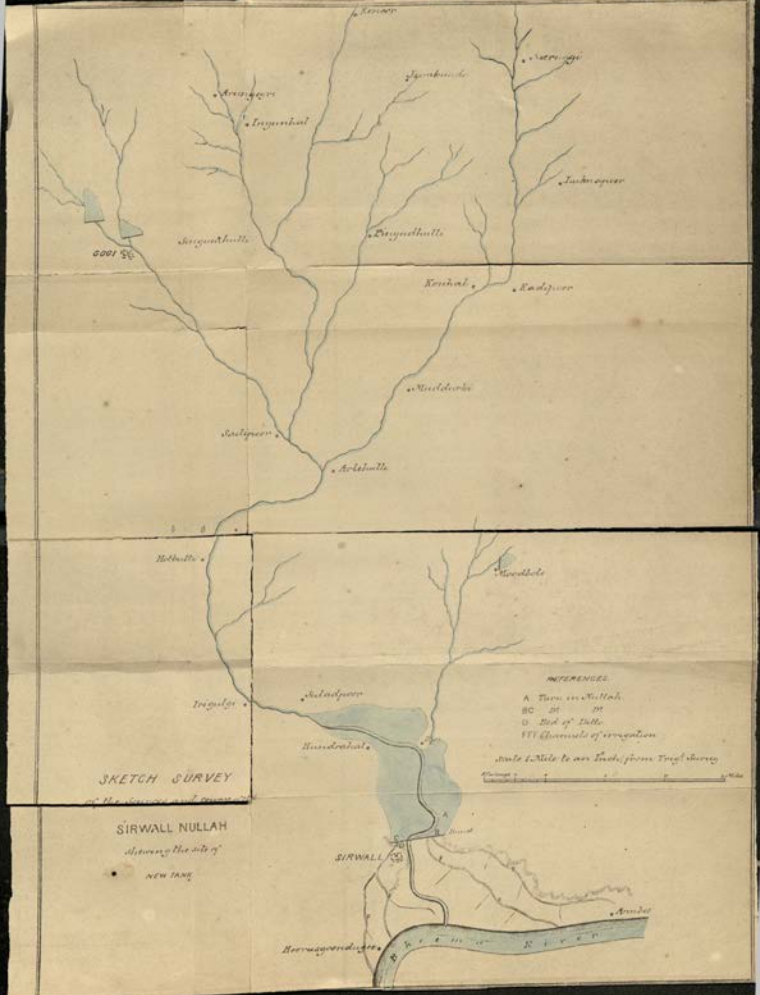
The tank will not be quite so large as this estimate, as I wish to save Itgi and Hundrahal. The estimate made lately to complete the work, with what had been already done, was in all 19,000 and odd Rupees; but a further addition to the fund will be considered when what is in hand is finished.

SKETCH SURVEY.

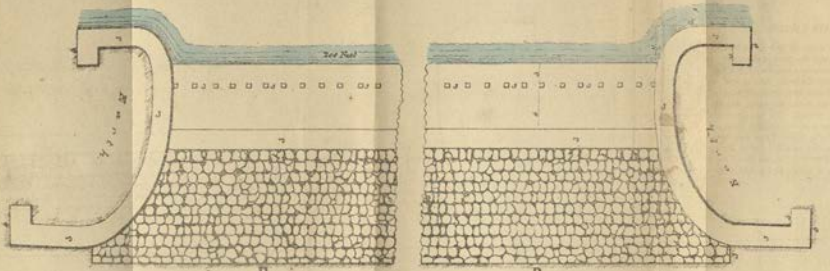
Shewing the Sources and course of the JEWURGEE NULLAH and proposed TANK.

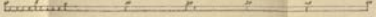
LIBRARY OF THE BOMBAY BRANCH OF THE ROYAL ASIATIC SOCIETY.

110124


Kerwar
Nagergaje
Jyambunde
Arsingeere
Ingumbal
Jachnageere
Sangunthulle
Bingunthulle
Kenhal
Kadigeere
Mudderdoke
Sadigeere
Arlathulle
Hubballe
Woodhole
Tirgulgy
Sulladgeere
Hundrahal
REFERENCES
A Turn in Nullah
BC ditto
D End of Dike
FFF Channels of irrigation
Scale 1 Mile to an Inch, from Trigl Survey
SKETCH SURVEY
SIRWALL NULLAH
showing the site of
NEW TANK
SIRWALL
Ambet
Heeraggendigeere
Krishna River

PLAN OF A CALINGULAH FOR A LARGE TANK





Signed M. Traylor
Copied from Captain Buckle
Supt. Engineer
H.S. Force
Secretary, 10th April 1862

MEMORANDUM BY CAPTAIN TAYLOR.

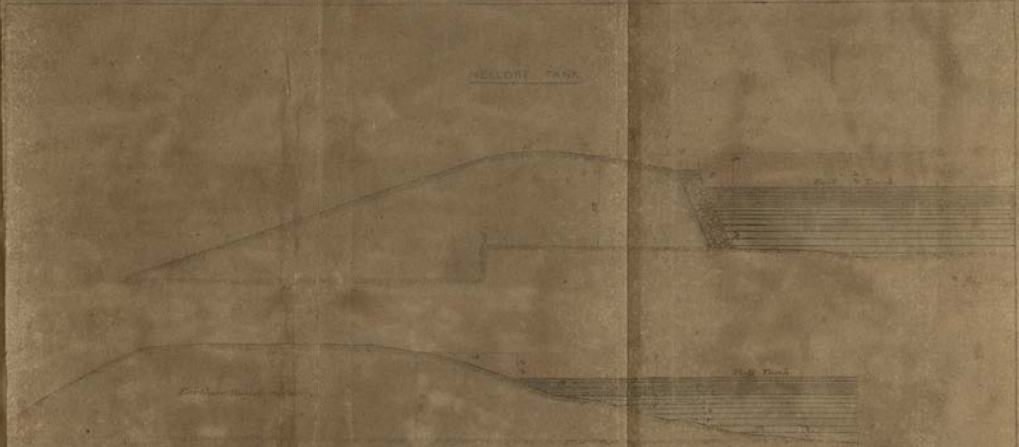
The intention of the peculiar form of the *apron* of this calingulah, as explained to me by Captain Buckle, is to diminish the force of the water as it escapes from the tank,—a precaution very necessary where the soil in which the calingulah is may happen to be soft. Thus the water running over at A is checked, and thrown up again at B, and runs level, or nearly so, over the pavement to C. The wall at C is to support the pavement, and the foundation should be carried down to strong ground. The upright stones allow of 2 feet water being retained in the tank by twisting branches between the stones, and backing them by clay or sods. Three feet, even, might be retained in this manner, when there would be still 3 feet to the top of the wing walls and bund. The pavement D D D should be of large rough stone. The rest may be of cut or squared stones, or concrete covered with fine chunam.

Jewurgee, 10*th April* 1852.

MEMORANDUM BY CAPTAIN TAYLOR ON SECTIONS OF THE BUNDS OF THE NELLORE AND WOJELLY TANKS, FROM CAPTAIN BUCKLE.

The Nellore tank is a very large one—I think about 6 square miles, but shallow. The bund is faced with stone. Here only 4 feet is left for safety, but the tank is closely watched, and on account of its shallowness does not throw up high waves.

The Wojelly tank is also a large one, and the Section is given to show a bund without stone. It will be seen that the base is in excess of the height. Such a bund could only be made of strong gravel and clay, or granitic soil, which binds strongly, and resists the action of water.


WELLORE TANK
WOJELLY TANK

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WITH YOU, RIGHT THROUGH

on 27 November, 2018